Health Physics Department. Annual progress report 1 Januar - 31 December 1985

Risø National Laboratory, Roskilde

Publication date:
1986

Document Version
Publisher's PDF, also known as Version of record

Risø-M-2557

HEALTH PHYSICS DEPARTMENT
Annual Progress Report
1 January - 31 December 1985

Abstract. The report describes the work of the Health Physics Department at Risø during 1985. The activities cover dosimetry, instrumentation, radioecology, risk by nuclear activities and nuclear emergency preparedness. Lists of staff and publications are included.

The main emphasis in the report has been placed on scientific and contractual work. Of lesser importance, but still quite significant, are the service functions.

October 1986
Risø National Laboratory, DK-4000 Roskilde, Denmark

ISBN 87-550-1282-5
ISSN 0418-6435

Grafisk Service Center 1986
Risø National Laboratory

CONTENTS

Page

1. INTRODUCTION

The Health Physics Department has the responsibility for some general functions at Risø: dosimetry, instrumentation, environmental monitoring, and health physics preparedness. The section for applied health physics, however, is part of the Safety Department.

The department is also responsible for more extensive education in health physics. Besides courses for the staff at Risø this includes shorter courses and lectures for nurses, fire brigade inspectors, naval officers and many others. Further, many of the staff members give lectures or otherwise assist in educational programmes at universities and give informative talks to societies and clubs.

For society at large, the department assists in answering questions and making statements or reports for the government and the central administration.

Finally, it should be mentioned that the department is represented in a number of international committees, the most important of which are listed in Appendix 2.

2. DOSIMETRY AND INSTRUMENTATION

2.1. Personal dosimetry

Risø's personal dosimetry service covers the individual monitoring of the personnel at Risø and the Niels Bohr Institute Tandem Accelerator. All workers and visitors staying at Risø for a period of more than two days are supplied with the Risø standard beta/gamma personal TLD badge. Additional dosemeters, e.g. fast neutron films, quartz fibre personal dosemeters, extremity dosemeters and criticality dosemeters are supplied according to special requirements. Urine samples are routinely collected in accordance with an established programme.

In 1985 approximately 2100 persons were monitored; of these 186 persons received doses above the registration level for external doses of 0.2 mSv (20 mrem). The total dose (collective dose equivalent) registered to the monitored personnel was 0.33 man Sievert (33 man rem). 10 persons received internal doses caused by intake of tritiated water. The contribution to the total dose from internal doses was 0.003 man Sievert (0.3 man rem). Figure 1 shows the distribution of the levels of the registered doses for 1985.

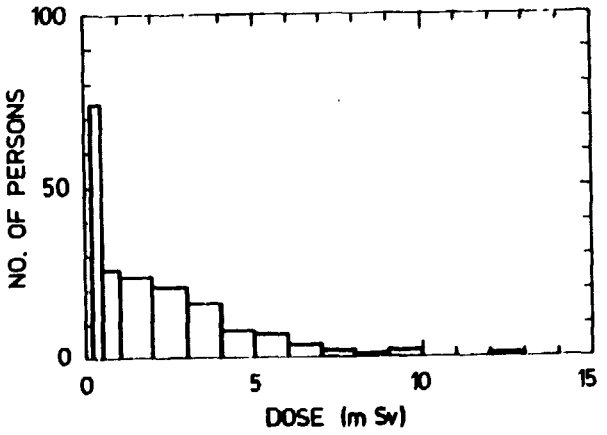

Fig. 1. Distribution of yearly whole body doses (effective dose equivalent) from 1985 for the Risø personnel.

2.2. Beta dosimetry

The investigations of energy and angular responses of TL dosemeters to beta radiations have continued. Results obtained with "thin", graphite-mixed MgB_4O_7:Dy detectors indicate that these detectors are usefull in determining the new ICRU quantity H'(0.07). A plan has been set up to intercompare these results with data obtained from similar measurements using extrapolation chambers carried out at N.R.P.B., UK and at P.T.B., Germany.

The group has assisted CEC in working out a programme for an extensive intercomparison programme of personal dosemeters for beta ray measurements, planned to take place in 1986. The laboratory will contribute to the programme by irradiating some of the dosemeters. A contract has been agreed upon with CEC concerning this work.

2.3. Nuclear track detectors

An image analysis system has been set up which is capable of automated counting and analysis of etched nuclear particle tracks in plastic. The system is composed of a microscope, CCD camera, frame grabber, personal computer, monitor, and printer. The frame grabber acquires and displays images at video rate. It has a spatial resolution of 512 x 512 pixels with 8 bits of digitization corresponding to 256 grey levels. The software has been developed for general image processing and adapted for the present purpose.

Initial comparisons of automated and visual microscope countings of tracks in chemically etched CR-39 detectors indicate that the automated system can be used safisfactorily for radon measurements (α-particle tracks) as well as for neutron dosimetry (proton tracks).

2.4. A nation-wide investigation of radiation doses in Danish houses

As a follow-up of the pilot survey of radiation levels in Danish dwellings in 1984 a nation-wide investigation was launched in 1985. This investigation, which is accomplished in co-operation with the National Institute of Radiation Hygiene, comprises 2 groups of 250 dwellings each.

The selection of dwellings was made by the National Institute of Radiation Hygiene, who also conducted liaison with the inhabitants.

The first group of the dwellings was monitored in the summer half-year from April to September. The monitoring of the second group started in the beginning of October and is scheduled to last until the end of March 1986.

The passive measurements of radon are made with the Risø cup dosemeter, which was tested in the pilot survey in 1983/84. Each dwelling has two cup dosemeters with CR39-foils. One of the cups also contains a TL dosemeter.

Preliminary results of the summer measurements indicate a log-normal distribution of radon levels with about one percent above 200 Bq m^{-3}.

2.5. Lifetime loss through lung cancer in Denmark and Sweden

The above-mentioned radon measurements seemed to indicate that the ratio of the average radon lung doses of Sweden to Denmark could be as high as 2. About 1/3 of all lung cancer cases in Sweden could be attributed to radon exposure according to the dose-effect relationship normally assumed.

On this background a comparative epidemiological investigation of the lung cancer burdens in Denmark and Sweden was carried out.

A measure termed the Collective Lifetime Loss (CLL) was used. It covers the total numbers of years lost due to death from the disease in question in a constructed group of 1000 newborns though their whole lifespan.

The overall CLL from long cancer turned out to be twice as high in Denmark as in Sweden, when each of the two countries is seen as a whole. In both countries CLL is 2.6 times higher for men than for women, and 1.8 times higher in the cities than in rural areas. Mortality figures for lung cancer are thus in parallel as far as the relations men/women and town/country are concerned. The fact that the general level of mortality is considerably higher in Denmark than in Sweden cannot be due to the difference in radon levels, as they are higher in Sweden than in Denmark.

2.6. Environmental dosimetry

As part of the environmental monitoring programme carried out by Risø, gamma background exposure levels at different sites in Denmark are routinely measured by means of LiF TLD-700 dosemeters. The integration times used are 6 months for zones surrounding the Risø facilities and 12 months for selected sites elsewhere in the country. The mean exposure levels, normalized to exposure rates, for different parts of Denmark in 1985 are given in the following table:

Location	Mean exposure rate (μR/h)*
Risø area	8.5
Zealand and islands	8.4
Jutland	7.6
Bornholm (Baltic island)	10.5

*) cosmic component is included

2.7. Phantom for internal dosimetry

The construction of the internal-dosimetry phantom was completed in 1985. It will be used for an experimental validation of internal dosimetry calculations for the Fisher-Snyder phantom.

To see how important the tissue equivalent simulation is, measurements have been made of the γ-dose rates in cylindrical organs submerged in different liquids. An aquarium of dimensions 80 cm x 30 cm x 20 cm simulated a "body". Two water-filled cylinders with 10 cm diameter and 13 cm height were representing the target and source organs. The target was supplied with 13 vertically mounted tubes containing a total of 39 TL dosemeters. Similary, the source cylinder was supplied with 7 tubes containing 21 TL dosemeters. Tissue equivalent liquid, water and alcohol were used as "body" liquid. The nuclides ^{60}Co, ^{134}Cs, and ^{203}Hg were used in the source organ. The maximum difference between the target dose rate with tissue liquid and water in the "body" was measured to be approximately 20% at large source-target distances.

For the lungs a liquid cannot be used as a substitute for lung tissue as the average lung density including air, tissue, and blood is in the range 0.25 - 0.30 g/cm^3. A suitable form of granulate will therefore be used as lung tissue substitute.

2.8. Instrumentation

The health physics instrument service covers routine calibration and maintenance of approximately 650 health physics survey instruments of which approximately 50 are positioned outside Risø as part of emergency arrangements. In addition, the instrumentation group is responsible for the working and calibration of area- and effluent monitoring systems installed at nuclear facilities at Risø.

2.9. Radon monitor

A semi-continuous radon monitor system was developed in connection with the research programme on radon monitoring of Danish houses. The monitor consists of a scintillation flask in connection with a photomultiplier and an electronic pulse counting system with printer. A small pump sucks an air flow through the scintillation flask and a continuous control of radon concentration is thus obtained by printing the integrated counts with preset time intervals. Five such complete continuous radon monitor systems were constructed.

2.10. Gas-flow multicounters for low-level beta counting

The development of gas-flow GM and proportional counters for low-level beta counting applications was continued in 1985 and resulted in improved versions of 5-element multicounter systems for the simultaneous counting of 5 samples of diameters of either 25 mm or 60 mm. An automatic high-voltage controller was incorporated in the GM-counter version that keeps the high voltage exactly on counting plateau in spite of varying gas flows and air pressure.

Two GM multicounter systems for the measurement of radioecological beta samples were produced and delivered to the Office of the Supervising Scientist, Darwin, Australia and to Deutsches Hydrographisches Institut, Hamburg, W. Germany, respectively.

2.11. TL instrumentation

The development of a new computer-controlled automated TL reader for routine processing of large numbers of solid TL dosemeters was started in cooperation with the National Institute of Radiation Hygiene. The reader is heated by hot N_2-gas and is based on loading with interchangeable cartridges that can

accommodate either 24 or 74 solid TL dosemeters. The dosemeters are measured automatically in selected sequences controlled by a personal computer in connection with a flexible software.

Two fully automated computer-controlled TL reader systems for TL dating, further developed with vacuum chamber, were constructed and delivered to the University of Adelaide, Australia and to Kernforschungszentrum Karlsruhe, W. Germany.

2.12. European intercalibration project

Calibration experiments, supported by the Directorate-General, Employment, Social Affairs and Education, CEC, Luxembourg were carried out at Risø, August 1985 with the aim of testing calibration methods for instruments used for background gamma radiation monitoring. The experiments comprised studies of 25 instruments from 11 European laboratories.

Two calibration methods using certified gamma sources were tested: a shadow-shield calibration method using a certified ^{137}Cs source, and a free-field calibration set-up using ^{137}Cs, ^{60}Co, and ^{226}Ra sources.

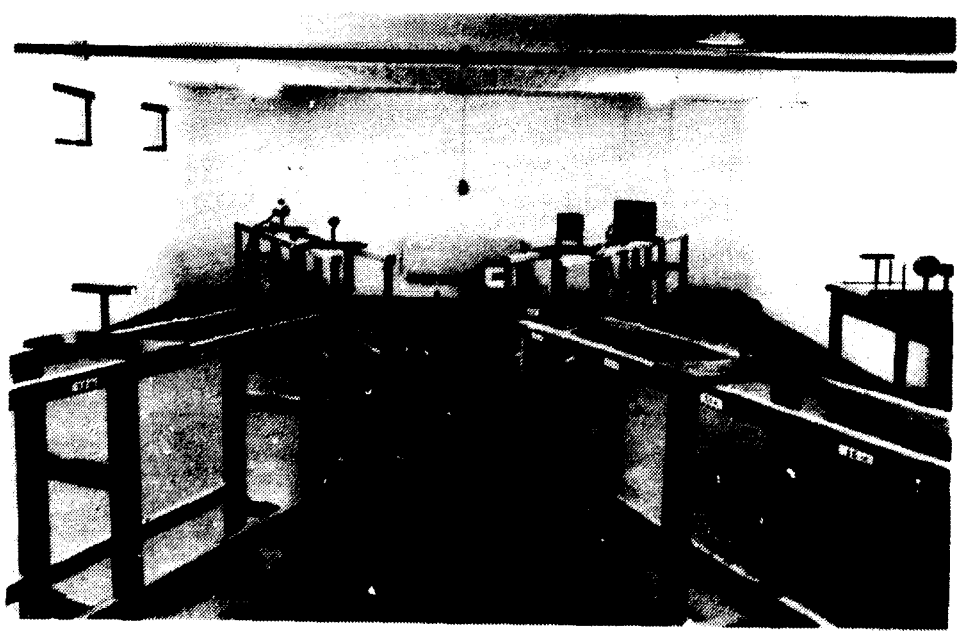

Fig. 2. Shadow-shield calibration set-up.

The shadow-shield experiments were arranged in a newly established cellar facility with four individual set-ups arranged on wooden benches with a common source position allowing for four individual measurements to be carried out simultaneously (see Fig 2). The free field experiments were arranged on a flat grass field with the sources and the instruments placed 1 metre above the ground.

For most of the instruments the two methods gave identical results. The shadow-shield calibration, however, proved to be more accurate (see Fig. 3). Additional measurements of the natural background and the cosmic component gave useful information on the energy dependency of the detectors.

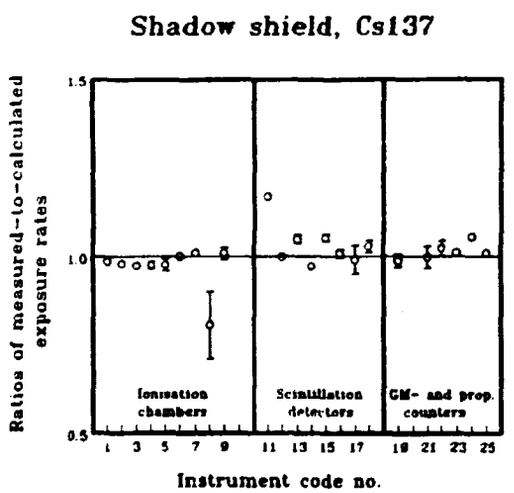

Fig. 3. Mean values of measured-to-calculated exposure rates from ^{137}Cs gamma radiation at the shadow-shield calibration measurements. The error bars give 95% confidence intervals.

List of publications

BØTTER-JENSEN, L., Environmental dosimetry practice at Risø National Laboratory, Proc. of XIII Yugoslav Symposium on Radiation Protection, Pula, June 10-13 1985, Vol. 2, 352-356.

BØTTER-JENSEN, L., Gas-flow multicounters for low-level and low-energetic beta counting applications. Paper delivered at ICRM low-level measurement techniques group meeting, June 3, 1985, Grenoble, France.

BØTTER-JENSEN, L., Åben multi-GM tæller for måling af lavenergetiske betaprøver. Paper delivered at 'Det fjerde nordiske radioøkologiseminar', Gol, Norway 27/2 - 1/3 85 (in Danish).

BØTTER-JENSEN, L. and MEJDAHL, V., Determination of potassium in feldspars by beta counting using a GM multicounter system, Nuclear Tracks, 10, 663-666 June 1985.

BØTTER-JENSEN, L. and NIELSEN, S.P., A multi-laboratory testing of calibration methods for environmental dose rate meters, Risø-M-2542.

CHRISTENSEN, P., Personal beta/gamma dosimetry at Risø National Laboratory, Proc. of XIII Yugoslav Symposium on Radiation Protection, Pula, June 10-13 1985, pp 348-351.

GJØRUP, H.L. and HANSEN, H.J.M., Levetidstab fra lungecancer i Danmark og Sverige, Nordisk Medicin, 100, 100-103, (in Danish).

LAUDRIDSEN, B. and HEDEMANN JENSEN, P., Experimental verification of internal dosimetry calculations. Construction of a heterogenious phantom based on human organs. Paper delivered at the 3rd International Symposium on Radiation Physics, Ferrara, September 30 - October 4, 1985.

MAJBORN, B., Measurements of radon in dwellings with CR-39 track detectors. Paper delivered at the 13th International Conference on Solid State Nuclear Track Detectors, Rome, Sept. 23-27 1985.

SØRENSEN, A., BØTTER-JENSEN, L., MAJBORN, B., and NIELSEN, S.P., A pilot investigation of natural radiation in Danish houses, Risø-M-2483.

SØRENSEN, A., BØTTER-JENSEN, L., MAJBORN, B., and NIELSEN, S.P., A pilot study of natural radiation in Danish houses, The Science of the Total Environment, 45, 351-356.

3. RADIOECOLOGY

3.1. Environmental radioactivity

The studies of environmental radioactivity were continued in 1985. Strontium-90 was determined in samples from all over the country of precipitation, ground water, drinking water, seawater, dried milk, grain, bread, potatoes, vegetables, fruit, total diet, and human bone. Furthermore, ^{90}Sr was determined in local samples of air, rainwater, marine sediments, grass, sea plants, fish, and meat. Cesium-137 was determined in air, precipitation, seawater, sediments, milk, grain products, potatoes, vegetables, fruit, total diet, sea plants, fish, and meat. Estimates of the mean content of radiostrontium and of radiocesium in the human diet in Denmark were given. Tritium was detemined in precipitation, fresh water and seawater. Plutonium and americium were measured in seawater, sediments, sea plants, and mussels.

The γ-background was measured regularly by TLD, ionization chamber and on site γ-spectroscopy at locations around Risø, at ten of the State experimental farms along the coasts of the Great Belt and around Gylling Næs.

The marine environment at Barsebäck and Ringhals were monitored for ^{137}Cs and corrosion products (^{58}Co, ^{60}Co, ^{65}Zn, ^{54}Mn).

Samples of various foods and drinking water from Greenland and the Faroes were analysed for ^{90}Sr and ^{137}Cs.

3.2. Dynamic models of the human food-chain

A data base containing concentrations of the fall-out nuclides ^{90}Sr and ^{137}Cs in different foodstuffs, in precipitation, and in air during the last 25 years have been applied in testing and improving a model for the pasture-cow-milk pathway. The

model, described in NRPB-R110, is now implemented on the Borroughs B7800 computer at Risø. Input parameters are handled on a separate file, thus making it easy to apply different sets of parameters. A program has been constructed which read data and constructs the necessary equations for solving the multi-compartment system of which the model consists. The program has access to a subroutine for solving the actual equations.

A comparison between measured and estimated activity in milk showed the need for more reliable parameters concerning Danish agricultural practice. Statistical data for milk production, fodder etc. were found and incorporated in the model when possible. This gave better results, but it was found necessary also to incorporate the variation in fallout levels both in precipitation and in milk between Jutland and the Islands to obtain better agreement between measured and predicted levels. For ^{137}Cs a reliable model could then be constructed showing the sensitivity to geographical variations. For ^{90}Sr this procedure was not insufficient to accomplish agreement between measured and predicted activity in milk. Therefore, a simpler model with fewer compartments was constructed reflecting, among other things, the Danish practise of ploughing relatively frequently. By a new determination of the transfer factors, still taking geographical variation into account, a reliable model was found.

The study was completed making a sensitivity analysis on some of the parameters including transfer factors, interception factor etc. This showed which parameters are the most crucial. When constructing separate models for Jutland and for the Islands good agreement was found between measured and predicted levels of activity in milk.

3.3. Uptake and loss of certain transuranium-, fission- and activation nuclides by Mytilus and Fucus

During 1985 the last samples from an earlier one-year loss experiment with Mytilus performed at the Forsmark Biotest facility at the Bothnian Sea were analysed. Radioisotopes of Mn, Co, Zn, Ag, Ce, Eu, Np, Pu, and Am were used. The results indicate that the more rapid losses in summer are not caused by higher temperatures, but rather mainly by seasonal variation in available nutrition. Americium was lost significantly more slowly than plutonium after the initial loss phase, whereas Eu/Am-ratios showed that europium could be used as an analogue for americium in this study.

In collaboration with Dr. N.S. Fisher (I.A.E.A., Monaco and Brookhaven, USA), experiments aimed at explaining the mechanism by which technetium accumulates strongly in brown algae have been initiated.

A model describing the accumulation and loss of radionuclides in Fucus as a function of month of discharge and month of sampling has been constructed. The validity of the model has been verified on an independent set of data on corrosion products in Fucus near the Swedish nuclear power plant Ringhals.

3.4. Determination of less well-known long-lived radionuclides

A new windowless gas-flow GM multicounter with four counting elements for measuring soft beta emitters has been constructed. Samples are placed inside the individual counter elements prior to sealing the counters and introducing a counter gas-flow. The windowless 4-channel multicounter that operates with a common guard counter has been developed to measure ultra-low energetic beta emitters such as ^{63}Ni samples prepared electrolytically on silver plates.

The radiochemical method developed at Lund University on ^{63}Ni is based on precipitation of Ni with dimethylglyoxim followed

by an ion exchange in 9M HCl which removes Fe and Co.

The counting equipment has a background of 0.25 cpm. The counter efficiency for a sample thickness of 0.35 mg cm^{-2} was 0.4 cps/Bq ^{63}Ni (β max = 0.07 MeV).

Methods for determining ^{63}Ni in environmental samples (seaweed, moss, lichen) is under development; as yet no results are available. One problem is being able to determine the chemical yields reliably.

Methods for determining ^{99}Tc and ^{237}Np in large-volume (~ 1-2 m^3) seawater samples are being developed. As chemical yield tracers ^{95m}Tc and ^{235}Np, respectively, have been applied. Samples collected at the "Polarstern" cruise in 1985 are under analysis for ^{99}Tc and ^{237}Np by the new methods.

3.5. Studies of transuranic elements, radiocesium, tritium and ^{60}Co in seawater sediments, seaplants and mussels in the North Atlantic region

In 1985 seaweed and seawater were obtained along the Channel coast from French-Danish-Swedish shore collections. Risø participated in the F/S Polarstern cruise to the Fram Strait in 1985.

The discharges of ^{60}Co, ^{99}Tc, and ^{106}Ru from the French reprocessing plant at Cap de la Hague have been traced in seaweed up along the Channel coast over a distance of 1200 km to SW-Denmark. The ^{60}Co concentrations were approximately inversely proportional with the distance (X) from Cap de la Hague. ^{99}Tc followed the regression: Bq kg^{-1} dry weight Fucus vesiculosus = 13 500 $X^{-0.6}$, where X is given in km.

Samples of Fucus collected at Thule, NW-Greenland, in 1984 contained enhanced ^{99}Tc levels. The presence of radwaste from European reprocessing plants have thus been demonstrated nearly 10 000 kilometers from the source.

Appart from Sellafield in the U.K., Cap de la Hague in France seems to contribute ^{99}Tc significantly. As expected a decrease in the ^{99}Tc in Danish Fucus samples in 1985 was observed. However, the decrease was half of that expected from the reduction in the Sellafield discharges from 1980 to 1981. This may be explained by a contribution from Cap de la Hague.

3.6. Environmental studies of plutonium and americium at Thule, Greenland.

The sediment samples were analysed for $^{239,240}Am$ by the conventional radiochemical methods using ^{242}Pu and ^{243}Am spikes.

Compared with 1979 the seawater Pu-concentrations have decreased by a factor of two in 1984. The levels found at Thule were not higher than those found southwards in the Baffin Bay, the David Strait and the Labrador Sea. Bottom water collected just over the point of impact at Thule contained enhanced Pu levels, but most of the activity was caused by particulates stirred up from the bottom. Hence it is concluded that the remobilization of Pu from the contaminated sediments at Thule to the water is insignificant.

The measurement of sediment samples (which is unfinished) indicates no change in the inventories estimated previously (~ 1 TBq $^{239,240}Pu$, 0.1 TBq ^{241}Am, and 0.015 TBq ^{238}Pu). Fucus samples from Thule contained 0.3-0.4 Bq $^{239,240}Pu$ kg^{-1} dry weight and Laminaria 0.1 Bq kg^{-1}. This is nearly two times less than the results from 1979. A Fucus sample from Grise Fjord in Canada showed the same concentrations of Pu as the Thule samples. This also proves the absence of any significant accidental contamination of the seawater of Thule.

Ten samples of shrimp collected at Thule were analysed for $^{239,240}Pu$ and ^{210}Po. The dose received from Pu was half of that from Po which again was 1 o/oo of the natural background radiation (including that from radon in houses) assuming an annual consumption of 10 kg shrimp flesh pro capita.

3.7. Long-term tagging of elvers, Anguilla anguilla, with radioactive europium

What happens to larval or small post-larval fish that are set out in the environment to secure a natural population? Do they ever reach maturity in amounts large enough to influence fishery in practice? In order to answer these questions one needs a fish mark that can be introduced through food or water and which will follow the animal during a major part of its further growth.

Elvers were labelled with ^{152}Eu and ^{155}Eu. Optimum conditions turned out to be incubation for 3 hours at 15°C in artificial seawater containing 2% NaCl and 0.1% KCl, $EuCl_3$ at 1 mCi (37 MBq)/l and an eel concentration of about 15%. Laboratory experiments pointed to a biological half-life of added europium of 1.6 ± 0.5 years.

1300 ^{155}Eu-labelled elvers (50 Bq/eel), each weighing on the average 0.21 g, were set out near Oskarshamn on the east coast of Sweden in June 1982. Three of these were caught nearby in May 1985 and one was caught in August 1985. Their average weight then was 56 g and they showed no significant loss of label other than attributed to the physical half-life (5.1 years). All the radioactivity was found in bone tissue.

3.8. Membrane lipids in the eel, Anguilla anguilla, by environmental factors

This project aims to study the mechanism of salt transport in marine animals and how this mechanism is affected by various environmental factors.

It has recently been shown in our laboratory that the $C_{16:1}$ fatty acid (palmitoleic acid) apparently plays a special role in the mechanism of salt transport by eel gills. This is in

accordance with the general concept that the lipid moiety of the cellular membrane has a modifying effect on transport proteins. It seems reasonable to expect changes in membrane function to be accompanied by changes in lipid metabolism within the cell system involved.

The gills are known to be the main site of active salt transport (against concentration gradients) in fish. In the eel, there is further evidence of a hormone-regulated passive salt transport (along concentration gradients) in the esophagus. The fish intestine is regarded as the site of both active and passive salt transport.

Present experiments compare lipid metabolism (in vivo) in the gills, esophagus, intestine and liver of the European eel (Anguilla anguilla). The liver acts as a reference tissue. Eels are kept in fresh as well as in seawater. They are caught either in their normal yellow stage or in their silver stage, which is when they are in a hormonal state ready for spawning migration from brackish water (Roskilde Fjord) to seawater. They are irradiated (10 Gy, total body) in a ^{60}Co-irradiation unit. Lipid metabolism is measured by adding ^{14}C-acetate and ^{32}P-phosphate as lipid precursors to the incubation tank. The various lipid classes from each tissue are separated and assayed by thin-layer chromatography. Fatty acids are separated and assayed by paper chromatography, after saponification and acidification.

3.9. Human uptake of chromium

In collaboration with the Chemistry Department at Risø and University Hospital in Copenhagen, the Health Physics Department has studied the uptake of ^{51}Cr-EDTA complex in the gut relative to the similar uptake of an array of polyethylenglycol molecules, in order to test the efficiency of the two uptake mechanisms as a tool in medical diagnosis. Test persons consisted of volunteers at Risø and patients with various intestinal diseases.

List of Publications

AARKROG A., BOELSKIFTE S., BUCH E., CHRISTENSEN G., DAHLGAARD H., HALLSTADIUS L., HANSEN H., HOLM E., MATTSSON S., and MEIDE A. Environmental radioactivity in the North Atlantic region in 1984. (The Faroe Islands and Greenland are included) Risø-R-528.

AARKROG A., BOELSKIFTE S., BØTTER-JENSEN L., DAHLGAARD H., HANSEN HEINZ and NIELSEN S.P. Environmental Radioactivity in Denmark in 1984, Risø-R-52, June 1985.

AARKROG A., BOELSKIFTE S., DAHLGAARD H., DUNIEC S., HALLSTADIUS L., HOLM E., and SMITH J.N. Technetium-99 and cesium-134 as long distance tracers in arctic waters. Submitted for publication in Estuarine, Coastal and Shelf Science.

AARKROG A., DAHLGAARD H., HANSEN H., HOLM E., HALLSTADIUS L., RIOSECO J., and CHRISTENSEN G. Radioactive tracer studies in the surface waters of the northern North Atlantic including the Greenland, Norwegian, and Barents Seas. Rit Fiskideildar, 9, 18-23.

BOELSKIFTE S. Dispersion and current measurement, an investigation based on time series analysis and turbulence models. (Ph D. thesis) Risø-M-2566.

BOELSKIFTE S. The application of Fucus vesiculosus as a bioindicator of ^{60}Co concentrations in the Danish straits. Jour. of Environmental Radioactivity, 2, 215-217.

HALLSTADIUS L., AARKROG A., DAHLGAARD H., HOLM E., BOELSKIFTE S., DUNIEC S., and PERSSON B. Plutonium and americium in Arctic waters and the North Sea, and the Scottish and Irish coasts. Journ. of Environmental Radioacticity, 4, 11-30.

HOLM E., AARKROG A., and BALLESTRA S. Origin and isotopic ratios of plutonium in the Barents and Greenland Seas. Earth and Planetary Sci. Letters, 79, 27-32.

4. ELEMENTS OF RISK BY NUCLEAR ACTIVITIES

4.1. Gaussian plume model

Development of Risø's computer model, PLUCON4, for calculating off-site consequences of releases of fission products to the atmosphere was continued.

PLUCON4 is used in a study of the sensitivity of dose pattern to grid size for population. This study is performed for the OECD/CSNI group GRECA. The final report is due in spring 1986.

Verification of the dose models included in PLUCON4 was continued. The report on the comparison of PLUCON4 calculations with data from tracer experiments at the Swedish nuclear power plant Ringhals is finished.

4.2. Puff model

A new model PUFFCON is being developed for calculating the consequences of accidental releases taking into account the variation of the meteorological conditions with time. This model is based on a puff dispersion model. It is a three-dimensional computer model which simulates the release of pollutant puffs and predicts their concentration as they diffuse while being advected downwind by a time- and space dependency. This work is partly financed by the Nordic Council of Ministers.

In 1985 dry and wet deposition have been included in the puff-model. Dry deposition of material is calculated using the source depletion concept. The dry-deposition parameters are chosen for the individual puffs according to the stability and windspeed governing the advection at a given time step.

Wet deposition is calculated using a wet deposition parameter depending on the actual rain intensity. The rain intensity is allowed to vary in time and space.

A simple model for calculating external gamma doses from airborne radioactivity has been developed. It is based on the semi-infinite cloud model with correction factors from Slade.

Further, a subprogram for calculating external gamma doses from deposited radioactivity will be included in the model. Thus, the final model will be able to calculate collective doses, consequences, etc.

The computer programs for calculating concentrations of airborne material and for graphical presentation of the results have been further developed.

A prototype dose/consequence model based on the puff model and the WASH 1400 consequence code CRAC2 has been developed. This work is partly financed by the Nordic Council of Ministers and the new model, NOCRAC, will be made available to all Nordic countries in 1986.

The puff-dispersion model, RIMPUFF, is tested in a benchmark study initiated by Kernforschungszentrum Karlsruhe. The study aims at quantifying strengths and weaknesses of more complex models. For this purpose, tasks for deterministic and probabilistic calculations have been defined.

The comparison of the probabilistic calculations is carried out on the basis of concentration, organ dose and consequence distributions obtained with an improved version of the ACA-code UFOMOD (ACA = Accident Consequence Assessment). The input data to UFOMOD are integrated air and ground concentrations for 3 different isotope types and 4 release phases. The meteorological data are hourly observations of wind speed,

wind direction, stability and rain intensity for 45 weather stations around the site of Biblis B (south of Frankfurt). A total of 95 representative weather sequences have been selected for the calculations. The calculations are partly financed by the CEC, and a final report is due in September 1986.

Verification of the puff model has continued with the simulation of two tracer releases from the Øresund experiment.

4.3. Radiological consequences of accidental contamination in urban environments

The areas for which major uncertainties exist for predicting radiological consequences of accidental releases of radioactivity especially concern the urban agglomerations.

As part of the CEC research programme MARIA (Methods for Assessing the Radiological Impacts of Accidents) and of the Nordic cooperation in nuclear safety, the Health Physics Department studies radioactive contamination with special emphasis on the urban environments.

4.3.1. External deposition

The experimental work has been concentrated on investigating the deposition velocities on building surfaces. Some are vertical surfaces of actual buildings where the surface deposition of fall-out ^{137}Cs is measured, others are artificial surfaces that are mounted on buildings to investigate the deposition velocity of ^{7}Be. The artificial surfaces are placed along the horizontal plane or at various angles to it. The ^{137}Cs deposition on 4 walls has been measured by means of a collimated Ge(Li) detector system by in situ measurements made at places where the artificial surface also has been mounted. The deposition velocities will be determined for the natural as well as for the artificial surfaces on the same spot.

A set-up of artificial plates under a bridge has given the following results for the deposition velocity, V_d: horizontal 0.03 cm/s, vertical 0.007 cm/s, and 35° slope against horizontal 0.02 cm/s. The rest of the deposition velocity measurements are on vertical surfaces, where the values are generally less than 0.001 cm/s.

The results indicate that deposition velocities on smooth urban surfaces are low, and that depositions on horizontal surfaces are higher than on vertical ones.

4.3.2. Ventilation, filtering, and internal deposition

The objectives of the work are to establish a more comprehensive methodological approach for assessing the consequences for people staying indoors during an accidental release of radioactive material. This is done by investigating various phenomena such as the filtering effect of houses, the ventilation rate, and the internal deposition.

A theoretical approach has been made in order to identify parameters that are essential in this respect. These were found to be λ_r the coefficient of ventilation in a building (fraction of air exchanged per unit time), λ_d the rate coefficient of deposition (fraction of aerosol in the building deposited per unit time), and f the filtering effect of the building (the fraction of aerosols retained in cracks, crevices, and pores on the way in).

In order to find f and λ_d considering that they are independent of λ_r, two measurements of the same building, with different λ_r, must be performed measuring the indoor and outdoor concentration.

A house has been studied using this method. It has a natural air exchange rate of about 0.1 h^{-1}, the filtering factor f was found to 0.5, and the deposition rate λ_d to 0.03 h^{-1}.

The transfer factor, D_{oi}, from outside to inside of the exposure integral can then be found as a function of the air exchange rate (Fig. 4).

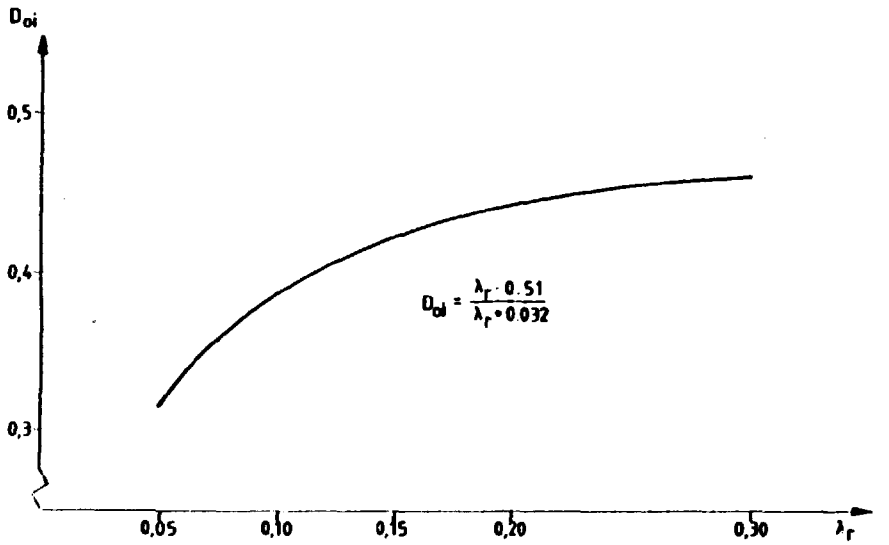

Fig. 4. The transfer factor, D_{oi}, from outside to inside of the exposure-integral as a function of the air exchange, λ_r.

4.3.3. Run-off from roofs

The effort to measure material that is removed due to run-off processes has been continued in 1985.

The measurement showed that the parts of ^{7}Be and ^{137}Cs that are removed with the run-off water have been raised considerably with the passage of time (Fig. 5). A possible explanation for this effect is that new building material traps the pollution relatively more efficiently due to a saturation effect.

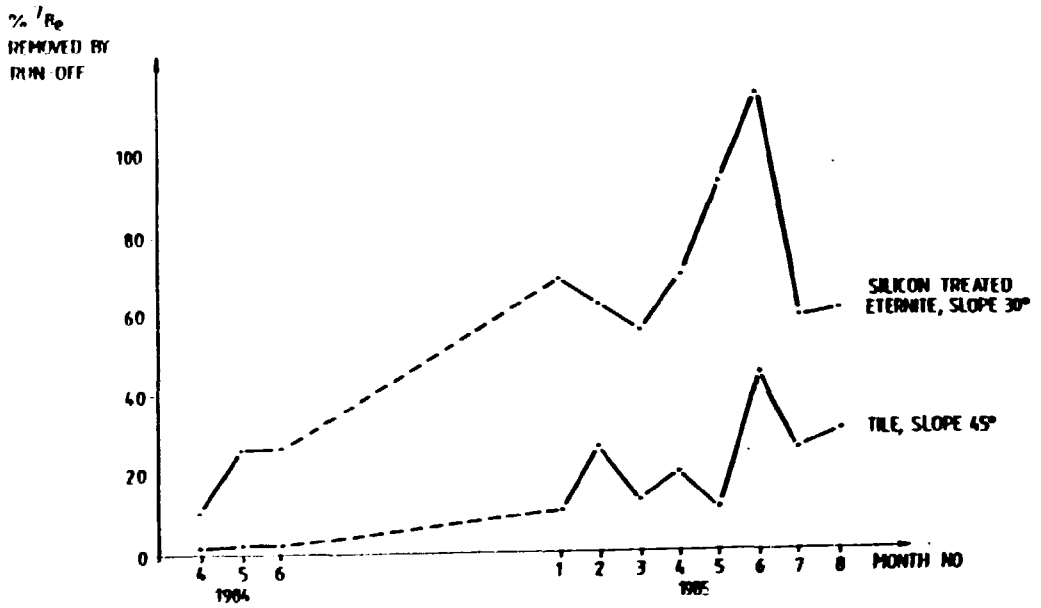

Fig. 5. The amount of deposited ^{7}Be removed with the run-off water.

As shown in Figure 6 the ratio of the concentration of ^{7}Be in run-off water to that in rainwater follows the precipitation rate fairly well. So by high precipitation rates the concentration, of ^{7}Be and ^{137}Cs in the run-off water, is close to that in rainwater.

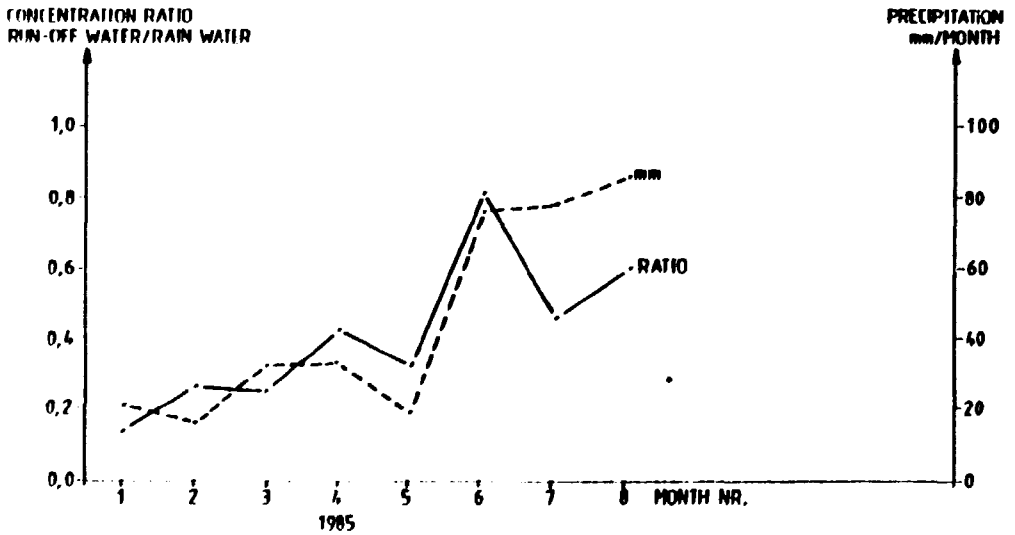

Fig. 6. The ratio of the concentration of ^{7}Be in run-off water to that in rain water during 8 months compared with the precipitation rate.

4.3.4. Forced decontamination

After experiments on decontamination of road surfaces with firehosing an experiment was carried out with "dry" decontamination. A so-called "shot blaster" was used. This machine has the advantage that the contaminated material loosened from the surface is collected in a container that can easily be removed to a disposal area.

The decontamination factor obtained was slightly above 2. This is more effective than most of the firehosing attempts.

4.4. Work for the Swedish State Power Board

The Swedish State Power Board, requested assistance to work out a method for calculating and describing the environmental consequences of severe core melt accidents.

A scenario for Ringhals 1 (a 780 MWe BWR of ASEA-ATOM design) was used as an example for describing the consequences.

The statistics from two years of meteorological measurements at the Ringhals mast were used in choosing suitable weather situations for the accident scenarios.

The PLUCON4 model was used for the calculations.

4.5. Computer modelling of radioactive source terms at a Tokamak reactor

The Monte Carlo code MCNP that treats an arbitrary three-dimensional configuration of materials has been used to set up a model of the first wall and the divertor a Tokamak reactor and to calculate neutron energy deposition.

The geometry is made according to the NET III A design in NET Activity Report No 34. The first wall material is stainless

steel AISI316 and the divertor materials are either stainless steel AISI316 covered with a 1 cm layer of copper and tungsten, or molybdenum blocks or tubes as proposed in the NET report.

The calculations have been made on a section representing 1/16 of the first wall and the divertor. The two boundary planes of the section are supposed to be reflecting.

The primary neutron source is given in the shape of a cylinder with its axis perpendicular to the central axis of the Tokamak. The void between the plasma and the first wall is simulated by low density tritium (1E-12 g per ccm).

The calculations are performed for 14-MeV neutrons assuming a neutron wall loading of 1.5 MW/sqm corresponding to a total neutron flux of about 5E19 neutrons per second. The calculations are performed for one second.

Apart from the geometry some other simplifications are presumed such as the neglect of inhomogenities of the Cu-W layer of the divertor. Furthermore, an even distribution of the neutrons on the first wall and the divertor walls is assumed.

The total energy depositions calculated are the sums of the energy deposition from neutron scattering and capture gamma. The gamma-ray energy loss is assumed to be deposited locally. The secondary electron transport is unaccounted for.

List of publications

GJØRUP H.L., JENSEN P. HEDEMANN, LAURIDSEN B., ROED J., and WARMING L. Deposition, Retention, and Decontamination of Radioactive Material on Urban Surfaces - Danish Programme. Workshop on Methods for Proceedings/Assessing the off-site Radiological Consequences of Nuclear Accidents. Luxembourg 15-19 April 1985. EUR 10397 EN, pp 463-491.

MILJØSTYRELSEN. Rapport om nedsættelsesfaktorer for doser ved ophold inden døre (in Danish).

NIELSEN F., THYKIER-NIELSEN S., and WALMOD-LARSEN O. Method for Calculations for Severe Accidents. Transient Accident with Safety Valve at Ringhals 1. Risø-M-2598.

ROED J. Reclamation of Urban Areas. Risø-M-2554.

ROED J. Reduction in Inhalation Dose by Staying Indoors. Proceedings of CEC Workshop on Methods for Assessing the Off-site Radiological Consequences of Nuclear Accidents. Luxembourg 15-19 April 1985. EUR 10397 EN, pp 559-600.

ROED J. Relationship in Indoor/Outdoor Air Pollution, Risø-M-2476.

ROED J., GJØRUP H.L., and PRIP H. Huses beskyttende virkning ved luftforureningsuheld (in Danish). Risø-M-2489.

THYKIER-NIELSEN S. Sensitivity of Dose Pattern to Grid Size for Population, SINDOC (85) 100.

THYKIER-NIELSEN S. and LARSEN S.E. Statusrapport ARTU 230 Videreudvikling og anvendelse af puff-model. (in Danish). Health Physics Dept., Risø National Laboratory, 1985.

THYKIER-NIELSEN S. (1985). Statusrapport REK 1-12: Udvikling af beregningssystemer for konsekvenser af store reaktorulykker. (in Danish). Risø National Laboratory, 19 July, 1985.

THYKIER-NIELSEN S., GRYNING S.E., and MORTENSEN N.G. (1985). Puff Diffusion Model Simulations of Two Tracer Releases from the Øresund-experiment: Paper delivered at Workshop on Real-time Computing of the Environmental Consequences of an Accidental Release to Atmosphere from a Nuclear Installation, Commission of the European Communities, Luxembourg, Sept. 17-20, 1985.

THYKIER-NIELSEN S., LARSEN S.E., MIKKELSEN T., EHRHARDT J., and PANITZ H.J. (1985). Consequences of a Nuclear Accidental Release Modelled by a Puff Model out to 200 km from the Source. Paper delivered at Workshop on Real-time Computing of the Environmental Consequences of an Accidental Release to Atmosphere from a Nuclear Installation, Commission of the European Communities, Luxembourg, Sept. 17-20, 1985.

WALMOD-LARSEN O. (1985) Exempel på beräknade omgivningskonsekvenser baserade på anläggningsspecifika studier. Konsekvensberäkningar. Lecture for Rådet för Kärnkraftsäkerhet, Stockholm, Seminar 1985-11-14. (in Swedish).

WALMOD-LARSEN O., JENSEN N.O., KRISTENSEN L., MEIDE A., NEDERGÅRD K.L., NIELSEN F., LUNDTANG PETERSEN E., PETERSEN T., and THYKIER-NIELSEN S. CARNSORE: Hypothetical Reactor Accident Study. Risø-R-427.

5. NUCLEAR EMERGENCY PREPAREDNESS

5.1. Risø

The external emergency plan for radioactivity accidents was further revised in 1985.

The plan was tested in an alerting exercise in September. The outcome of the exercise was considered to be satisfactory.

5.2. Barsebäck power plant

On May 9th and 10th a two-day Swedish-Danish Barsebäck emergency exercise "EPSILON" took place. The activities planned led to actions from almost all institutions and authorities involved according to the emergency planning.

On the first day the new "Standby alert" was practised, thus involving only the different staffs. For the second day, a release from the plant was supposed to pass along the Sound and give rise to the need for implementation of protective actions in both countries.

Further to its foreseen role in the Technical Emergency Service during the exercise, the Health Physics Department was involved in the detailed planning of the exercise as well as in the evaluation of it.

5.3. Argos

The ARGOS (Accident Reporting and Guiding Operational System) is a computerized system for communicating and presenting monitoring data and related dose calculations. The system is under development in cooperation with the Danish Environmental Agency.

ARGOS was used for the first time in exercise "EPSILON". Two identical computers were installed, one at police headquarters in Copenhagen and one at Risø. Terminals at the Civil Defence Corps unit at Hillerød and the Malmö County Emergency Command were connected. At all four places measurements could be fed into the system. From the computers in Copenhagen and at Risø maps with isodose-rate curves were frequently drawn for relevant areas and periods.

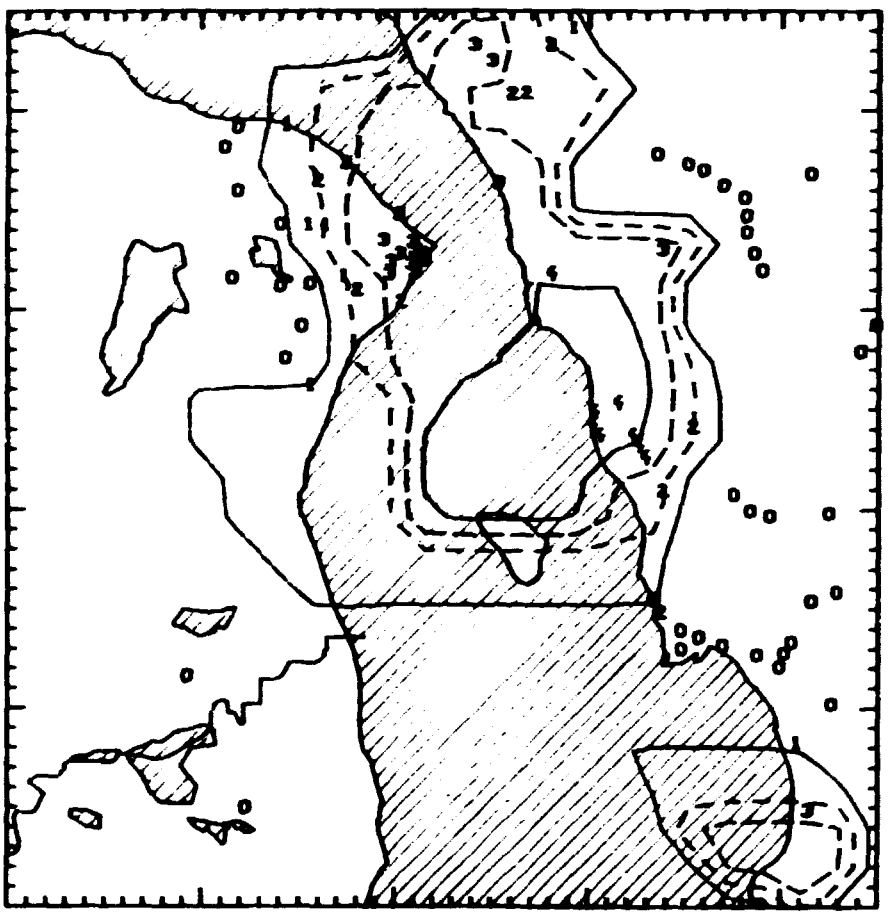

Fig. 7. ARGOS map showing North-east Zealand, the Sound (here hatched), and part of Sweden. On the original the measuring points and the isodose-curves appear in colours according to a code for dose rate intervals.

List of publications

LIPPERT J. Computer system for data communication, presentation, and dose calculation". Paper delivered at Workshop on Real-time Computing of the Environmental Consequences of an Accidental Release to Atmosphere from a Nuclear Installation, Commission of the European Communities, Luxembourg, Sept. 17-20, 1985.

LIPPERT J., WALMOD-LARSEN O., and JEPSEN JOHS. ARGOS: An Emergency preparedness computer system for data communication, presentation, and dose calculations at nuclear emergencies. Paper delived at IAEA International Symposium on Emergency Planning and Preparedness for Nuclear Facilities, Rome 4-8 Nov. 1985. IAEA-SM-280/23.

Appendix 1.

STAFF OF THE DEPARTMENT

Scientif Staff
(number refers to the relevant sections of this report)

Boelskifte Petersen, S. (3)
Bøtter-Jensen, Lars (2)
Christensen, Poul (2)
Dahlgaard, H. (3)
Furuta, Sadaaki
Gjørup, H.L. (Head of the department)
Hansen, Heinz (3)
Jensen, Per Hedemann (2,4)
Lauridsen, Bente (2,4)
Lippert, Jørgen (2,5)
Majborn, Benny (2)
Meide, Annelise (4)
Nielsen, Flemming (4,5)
Nielsen, Sven P. (2,4)
Roed, Jørn (4)
Sørensen, Arne (2)
Thykier-Nielsen, S. (4,5)
Vinther, F. Heikel (4,5)
Walmod-Larsen, Ole (4,5)
Warming, Lisbeth (4)
Aarkrog, Asker (3)

Technical Staff
Ahleskov, Eva
Berg, Birthe
Bitsch, Gunnar
Brandstrup, Oda
Brisson, Steen
Brøns, Per A.

Baade-Petersen, Pearl
Christensen, Tove
Christiansen, Henrik
Clausen, Jytte
Ebling, Elise
Frost, Ellen Margrethe
Hansen, Elly
Hansen, Lissie Sture
Hougaard Pedersen, Henrik
Jensen, Karen Mandrup
Jensen, Rita S.
Jensen, Svend Åge Winfeldt
Jepsen, Johs.
Jørgensen, Finn
Jørgensen, Vibeke
Kjølhede, Alice
Lange, Rolf
Larsen, Tommy Bomand
Madsen, Anna
Mundt, Helge Chr.
Olsen, Signe
Pedersen, Anna Holm
Pedersen, Finn
Porsdal, Helle
Prip, Henrik
Rabe, J.H.
Roig, Joaquin
Sørensen, Else Marie
Sørensen, Lis
Wie Nielsen, Karen
Willumsen, Finn

Office Staff

Kristensen, Ingrid

Nielsen, Margit

Ullrich, Elisabeth

Appendix 2.

PARTICIPATION IN INTERNATIONAL WORKING GROUPS, etc.

IAEA, The International Atomic Energy Agency

Advisory Group on Post-Accident Assessment and Recovery Operations in a Radiation Environment (Hedemann Jensen).

OECD, Nuclear Energy Agency

Committee on Radiation Protection and Public Health (Gjørup)

Committee Core Task Group, CRPPH/ICRP Interaction (Gjørup)

CSNI: Principal Working Group IV (Gjørup)

do. Subgroup of Experts on Accident Consequences (Thykier-Nielsen)

CSNI: Working Group on Fuel Cycle Safety (Roed)

Executive Group for Research on Sea Disposal of Radioactive Waste (Aarkrog)

do. Radiological Surveillance Task Goup (Dahlgaard)

Commission of the European Communities

Article 31 Committee, Basic Safety Norms (Gjørup)

Article 31 Working Group concerning Sellafield (Gjørup)

Article 37 of the Euratom Treaty, Group of Experts (Walmod-Larsen)

CGC on Radiation Protection (Gjørup)

do. Expert Group C on the Atmospheric Fission Product Dispersion following a Reactor Accident (Thykier-Nielsen).

Expert Group on Safety and Environment for the European Fusion Programme (Warming).

Expert Group on Transfrontier Emergency Planning (Walmod-Larsen)

Group of Technical Experts on Radiation Protection Dosimetry (Christensen and Majborn)

EURADOS, Beta- and Low-Energy Photon Dosimetry (Christensen)

EURADOS, Personal TLD Dosimetry (Christensen)

European Atomic Energy Society:

Public Relations Correspondents Group (Walmod-Larsen)

International Committee for Radionuclear Metrology (S.P. Nielsen)

Nordic Cooperation:

SNODAS (coordination of Nordic dose calculations and atmospheric dispersion models) (Hedemann Jensen, Thykier-Nielsen)

Risø National Laboratory

Risø - M - 2557

Title and author(s)

HEALTH PHYSICS DEPARTMENT
Annual Progress Report
1 January - 31 December 1985

Date October 1986

Department or group

Health Physics

Groups own registration number(s)

Project/contract no.

Pages 41 Tables Illustrations 7 References

ISBN 87-550-1282-5

Abstract (Max. 2000 char.)

Abstract. The report describes the work of the Health Physics Department at Risø during 1985. The activities cover dosimetry, instrumentation, radioecology, risk by nuclear activities and nuclear emergency preparedness. Lists of staff and publications are included.

The main emphasis in the report has been placed on scientific and contractual work. Of lesser importance, but still quite significant, are the service functions.

Descriptors

INIS Descriptors
DOSIMETRY; RADIATION PROTECTION; RADIOECOLOGY; RESEARCH PROGRAMS; RISOE NATIONAL LABORATORY

Available on request from Risø Library, Risø National Laboratory, (Risø Bibliotek, forsøgscenter Risø), P.O. Box 49, DK-4000 Roskilde, Denmark.
Telephone (02) 37 12 12, ext. 2262. Telex: 43116, Telefax: (02) 36 04 09